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FILTER OPERATION[1]

By S. M. Van Loan and Albert Tolson

Conditions governing the operation of filters are not changing to any marked extent as time passes, but the methods adopted to cope with situations have naturally been in a progressive stage. Each year teaches a filter operator a lesson, and a season should not pass wherein some economy or some improvement could not be suggested.

The tendency of health commissions to protect watersheds from harmful influences which may bear directly or indirectly upon the content of rivers supplying water to our purification works, has given much encouragement to water works officials, and with the advance of improvement in the raw supply, the load on each filter plant is reduced.

Popular demand centers upon a clear water service and adverse comment seldom manifests itself when a water works furnishes a sparkling supply throughout its distribution system. Few residents of a large community have any conception of the appearance or harmful content of unfiltered water, and a filter superintendent must have his plant in such a state of preparedness that it may cope with one load or several should there be a repetition of unusual conditions during a short period of time.

As water passes to a distribution system, the task of determining the quality is imposed upon the laboratories. The registering of results in a speedy way gives the plant operator evidence to correct many troubles that might assume serious proportions should warnings be neglected. The analysis of raw waters is valuable more as a matter of record than as an influence in operation.

At the Delaware unit, Torresdale, the raw water has been applied without treatment or sedimentation. Upon occasions when the elements of wind, tide and temperature have entered, the supply of water from the pumping station has been below the demand of the plant. The water on the sand surface decreases in depth and all filters with a high loss of head automatically decrease in rate. In order to keep the plant in operation these filters are washed, the greater the loss of water on the sand the more frequent the washing, resulting in an increased amount of wash water and power. High winds frequently create waves which scour the river banks causing increased turbidity and the natural sequence is shorter runs and more frequent washings.

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[1] Read at meeting of New York Section, December 15, 1915.

At the time of writing, a basin which will admit of 12 hours' sedimentation is under construction, and with the application of a coagulant it is expected to materially reduce turbidities and bacteria in the water applied to the preliminary filters.

These filters are of a rapid sand type operating at an 80 mg. rate through 30 inches of graded gravel and 12 inches of 0.8 to 1.0 mm. sand. Air and water for washing are admitted through a $\frac{3}{16}$-inch orifice on under side of pipe so spaced that each wash influence must control 33.1 square inches.

Observations to determine the depth of sand on the prefilters have been taken at various times and after a three year period of operation it was noticed that from 1 to 3 inches of sand had been lost and subsequent inspections indicated there had been a reduction of sand depth at the rate of 1 inch per year. The greater proportion of this loss was due to the escape with mud removed during washing, and the remaining loss has been carried down through the gravel into the under drains finally lodging in the controllers. Many of the $\frac{3}{16}$-inch orifices are closed with rust or dirt and the lateral piping is becoming choked with barnacles. The cast iron manifolds were not tapped, in consequence of which the sand and gravel immediately above receive no influence from air or wash water. As a result this sand becomes so charged with mud that it has been found necessary at times to remove it with shovels and replace with clean sand. Caps are placed on the ends of the lateral piping forming dead ends where rust and other matter accumulate, clogging the holes near the extremities. As the capped ends of these pipes are spaced 3 inches from those of the adjacent series the volume of unwashed sand and gravel above will gradually increase until a considerable area of sand throughout the filter gives no service.

Experiments to determine the efficiency of different sand depths upon these preliminary filters have been conducted for several years and then contrasted with the percentage removed by the entire set of beds. These records show 49, 84 and 68 per cent efficiency respectively for a 3-inch depth, an 18-inch depth and the average depth of 9 inches over the combined area. From the results obtained by these experiments it was decided to increase the depth of sand to 18 inches on all the preliminary filters at this station. A contract has been let for a sufficient quantity of sand to furnish each filter with a depth of 17 inches. Before placing it will be necessary to raise the wash water troughs and gullet 6 inches, which work is now being done.

The demand for water from the Torresdale plant requires an average rate through the final filters of about 4,500,000 gallons per acre, and the present year has given the plant its heaviest load, as the dredging for the new basin has forced a heavily charged water upon the prefilters which unit has not, on account of sand deficiency as described above, performed efficiently. Deep cleaning of final filters is routine work at this plant and a "house-cleaning" is necessary at least every two years, at which time a layer of sand just sufficient to protect the gravel is left undisturbed.

Schuylkill water at Philadelphia readily yields to filter purification. After a severe local storm a water charged with a heavy yellow, suspended matter is encountered. This soon clarifies itself and has very little effect upon the filters. A severe general storm produces first a heavy, red water, followed closely by one charged with coal dirt from the mining regions, which water is hard to clear, at times carrying a very disagreeable gaseous odor and taste. Aeration and sedimentation reduce the gas, but when the water is heavily charged much passes through the filters and carries to the house spigot. Naturally many complaints from the consumers are registered and all sorts of alleged disorders from its effects are reported.

The Schuylkill units are provided with sedimentation basins and have, in addition, the aid of a coagulant at times of heavy turbidities. This river rises rapidly after a heavy storm and it is upon the slow or rapid rise and extent of the storm that the superintendent decides whether to start dosing. A high turbidity of short duration will require no coagulant, while one much lower covering an extended period of time will necessitate its use.

At Queen Lane the preliminary filters are of the same type as those at Torresdale. The wash water is applied through $\frac{3}{4}$-inch brass strainers 3 inches long containing $\frac{3}{16}$-inch holes discharging horizontally from the top. These strainers are inserted in slabs of reinforced concrete at 9-inch centers above the main and lateral collectors. Around and above these strainers is placed 15 inches of graded gravel and 12 inches of 0.8 to 1.0 mm. sand. The air is applied through 1-inch brass piping between the second and third layer of gravel or about 23 inches below the normal sand surface. This piping is tapped on the under side with $\frac{1}{8}$-inch holes spaced 6 inches apart and the pipe is set on 9-inch centers making an area of 54 square inches under the control of each orifice. Air and water can be used jointly or separately. After three years of service an increased depth of sand was observed in the beds. Further inspection developed the fact that the sand and gravel were abnormally charged with mud at such points in the filter not well under the control of the washing influence. No sand of any quantity has been lost and on the contrary this increased depth was recorded. These filters were developing a 70 per cent efficiency but the presence of large cracks upon the sand surface after a washing led to the thought that the sand character was changing.

The low rate demanded from this filter allowed too extended a run and when the loss of head on the bed indicated the end of a run, a filter highly charged with mud was presented. The regular wash was considered sufficient to clean for another long run. This rise in the sand surface showed an apparent depth of 16 inches of sand where only 12 inches had been placed.

Experiments were made to wash the filters more frequently, also to combine the air and water in washing. Neither cleaned sufficiently, and finally it was decided to spade the sand to a depth of about 12 inches with coke forks, following with a raking of the surface and then washing in the ordinary manner. The filters at this station operate at about a 50,000,000 gallon rate and run about five or six days between washings, a 4.5 foot loss of head marking the limit of run. The more frequent cleanings have now been resorted to, one-third of the plant being washed each day, giving each filter a three-day run with a maximum loss of head of about two feet. This method is very slowly but surely improving the situation. The application of the air and wash water at the same time is hardly feasible as it forced the $\frac{1}{8}$-inch gravel into the sand and caused considerable loss of sand in the wash water troughs and gullet. The spading of the sand has broken up the mud and has been the means of eliminating a number of the cracks.

Considerable trouble has been experienced with the sticking of rate controllers at Torresdale. This is caused by the presence of sand grains between the side of the piston and the piston chamber. Efforts have been made to keep the controllers working freely by turning them several times daily with hand wheels, but as an unreliable human element enters at this point, it proved unsuccessful. These pistons are now being removed and turned down $\frac{1}{16}$ inch, decreasing their diameter. This permits the sand drains to pass and prevents the piston from sticking in one position. At the present time all the controllers so treated are working satisfactorily.

The Philadelphia filters are located at a considerable distance from the residence section of the city, and often, during times of bad travel, the work of operating filters is seriously interfered with by shortage of labor. At times this shortage is overcome by working additional hours, but, as city labor receives one and a half time or double time for such work, economy of operation does not result.

Constant attention to the depth and condition of the filtering materials is most important. Thorough inspection of each filter unit should be a matter of routine work. Upon one occasion after a long period of dry weather, a storm produced a heavily charged river, the final filters at one of the stations went out of service rapidly and after being cleaned, short runs ensued. Inspection showed subsurface clogging of the sand. The lower 2 to 5 inches of sand above the gravel was compact and dirty, above which was found a layer of clean sand and in order layers of clean and dirty sand alternated every few inches until the sand surface was reached.

In order to remove the subsurface layers the entire body of sand extending to the gravel was washed. This is the third time it has been found necessary to wash the full depth of sand in the filters at this plant. This subsurface clogging is caused by placing clean sand upon the old unwashed content. The undisturbed sand appears clean but the voids are partly filled with the gelatinous matter removed from the water in past runs, and, as the unwashed sand is more compact, due to this foreign matter and also to the workmen walking upon it, it offers greater resistance to the water passing through than the newly washed sand above. The suspended matter passing through the upper layer of the clean, loose grains will be caught and retained by the more compact layer beneath. When this under layer becomes too dirty to permit the desired quantity of water passing, a deeper scraping is needed to give it life.

Sometimes during periods of low turbidity a superintendent finds his filters of the slow sand type producing long runs, the loss of head increasing slowly or at times decreasing. With a sudden rise in turbidity of the applied water the loss of head leaps and the plant's capacity is so reduced that every means is adopted to supply the demand for water. One experience of this kind will be sufficient to teach a superintendent to keep enough units of his plant in condition to meet any and all requirements.

In washing the sand in slow sand filters by separating and ejecting methods a quantity is carried off by the wash water and is retained in bins erected on the courts of the plant. A large percentage of this sand is too fine to be replaced in the beds, and an effort has been made to separate it from the sand of desirable size. These efforts have not been entirely successful and when the sand is removed from the courts and placed in a filter, short runs will ensue until a turning over is accomplished by a subsequent cleaning. The undesirable fine sand on the courts is removed from the plant and discarded.

Deep cleanings of slow sand filters should be avoided as much as possible in the winter months. Experience has proven that a filter will give much better service when the sand is washed before cold weather sets in than it will when washed deeply in the winter.

Chlorine apparatus is attached to each plant and a low degree of dosing (½ pound per million gallons) is applied upon the Schuylkill plants throughout the greater portion of the year. At times when general rains have scoured the water shed contributing to the respective rivers, a heavier dosing is applied more particularly as a precautionary measure. The maximum quantity used at the Schuylkill plant is one pound of chlorine per million gallons of water. On account of the disturbance of dredges the dosing at Torresdale has been at the rate of 1¾ pounds per million gallons.

The point of chlorine application at all stations is at the inlet gate house of the filtered water basins. No extra labor is required for this service and the character of water at remote locations in the distribution system, many miles from the filter plant, is highly satisfactory bearing the endorsement of the state and city health departments.